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RADIAL EXPANSION OF TUBULAR MEMBERS

Background of the Invention

This invention relates generally to the coupling of expandable tubular members to preexisting structures such as wellbore casings.

Conventionally, when a wellbore is created, a number of casings are installed in the borehole to prevent collapse of the borehole wall and to prevent undesired outflow of drilling fluid into the formation or inflow of fluid from the formation into the borehole. The borehole is drilled in intervals whereby a casing which is to be installed in a lower borehole interval is lowered through a previously installed casing of an upper borehole interval. As a consequence of this procedure the casing of the lower interval is of smaller diameter than the casing of the upper interval. Thus, the casings are in a nested arrangement with casing diameters decreasing in downward direction. Cement annuli are provided between the outer surfaces of the casings and the borehole wall to seal the casings from the borehole wall. As a consequence of this nested arrangement a relatively large borehole diameter is required at the upper part of the wellbore. Such a large borehole diameter involves increased costs due to heavy casing handling equipment, large drill bits and increased volumes of drilling fluid and drill cuttings. Moreover, increased drilling rig time is involved due to required cement pumping, cement hardening, required equipment changes due to large variations in hole diameters drilled in the course of the well, and the large volume of cuttings drilled and removed.

The present invention is directed to overcoming one or more of the limitations of the existing procedures for forming wellbores and other preexisting hollow structures.

Summary of the Invention

According to a first aspect of the present invention, there is provided a method of coupling an expandable tubular member to a preexisting structure comprising positioning the tubular member and an expansion cone within the preexisting structure, anchoring the tubular member to the preexisting structure axially displacing the expansion cone relative to the tubular member by pulling the

expansion cone through the tubular member and lubricating the interface between the expansion cone and the tubular member.

According to a second aspect of the present invention, there is provided a system for coupling an expandable tubular member to a preexisting structure comprising means for positioning the tubular member and an expansion cone within the preexisting structure, means for anchoring the tubular member to the preexisting structure, means for axially displacing the expansion cone relative to the tubular member by pulling the expansion cone through the tubular member and means for injecting a lubricating fluid into the trailing edge of the interface between the expansion cone and the tubular member.

According to a third aspect of the present invention, there is provided a system for coupling an expandable tubular member to a preexisting structure comprising means for positioning the tubular member and an expansion cone within the preexisting structure, means for anchoring the tubular member to the preexisting structure, means for axially displacing the expansion cone relative to the tubular member by pulling the expansion cone through the tubular member and means for lubricating an interface between the tubular member and the expansion cone with a lubricant.

In the first and third aspects of the present invention, the lubricating may include injecting lubricating fluid into the interface between the expansion cone and the tubular member.

The lubricating fluid may have a viscosity ranging from about 1 to 10,000 centipoise. Preferably, the injecting includes one or more of injecting lubricating fluid into a tapered end of the expansion cone, injecting lubricating fluid into an area around an axial midpoint of a first tapered end of the expansion cone, injecting lubricating fluid into a second end of the expansion cone, injecting lubricating fluid into an interior of the expansion cone, injecting the lubricating fluid through an outer surface of the expansion cone and/or injecting the lubricating fluid into a plurality of discrete locations along a trailing edge portion of the expansion cone.

The lubricating fluid may comprise drilling mud and may further include TorqTrim III, EP Mudlib and DrillN-Slid. Alternatively, the lubricating fluid may comprise TorqTrim III, EP Mudlib and DrillN-Slid.

In the first and third aspects of the present invention, the lubricating may comprise coating the interior surface of the tubular member with a lubricant. Preferably, the lubricating includes coating the interior surface of the tubular member with a first part of a lubricant and applying a second part of the lubricant to the interior surface of the tubular member. The lubricant may comprise a metallic soap. The lubricant may be selected from the group consisting of C-Lube-10, C-PHOS-58-M, and C-PHOS-58-R.

The lubricant used in the present invention preferably provides a sliding friction coefficient of less than about 0.20. The lubricant may be chemically, mechanically or adhesively bonded to the interior surface of the tubular member. The lubricant preferably includes epoxy, molybdenum disulfide, graphite, aluminum, copper, alumisilicate and polyethylenepolyamine.

The tubular member may include an annular member, including a wall thickness that varies less than about 8 %; a hoop yield strength that varies less than about 10 %; imperfections of less than about 8 % of the wall thickness; no failure for radial expansions of up to about 30 %; and no necking of the walls of the annular member for radial expansions of up to about 25%.

The tubular member may include a first tubular member, a second tubular member and a pin and box threaded connection for coupling the first tubular member to the second tubular member, the threaded connection including one or more sealing members for sealing the interface between the first and second tubular members. Preferably, the one or more sealing members are positioned adjacent to an end portion of the threaded connection. Alternatively, there are at least two sealing members and one of the sealing members is positioned adjacent to an end portion of the threaded connection and another one of the sealing members is not positioned adjacent to an end portion of the threaded connection. Alternatively, there is a plurality of sealing members and some of them are positioned adjacent to an end portion of the threaded connection.

The tubular member may include a plurality of tubular members having threaded portions that are coupled to one another by the process of coating the threaded portions of the tubular members with a sealant, coupling the threaded portions of the tubular members and curing the sealant. Preferably, the sealant is selected from epoxies, thermosetting sealing compounds, curable sealing compounds and sealing compounds having polymerizable materials. The sealant may be initially cured, prior to radially expanding the tubular members and finally cured after radially expanding the tubular members. Advantageously, the sealant may be stretched up to about 30 to 40 percent after curing without failure, may be resistant to conventional wellbore fluidic materials, and the material properties of the sealant may be substantially stable for temperatures ranging from about 0 to 450°F (about –18 to 227°C).

A primer may be applied to the threaded portions of the tubular members prior to coating the threaded portions with the sealant. Alternatively, the primer may be applied to the threaded portion of one of the tubular members and the sealant to the threaded portion of the other one of the tubular members. The primer may include a curing catalyst.

The tubular member may include a pair of rings for engaging the preexisting structure and a sealing element positioned between the rings for sealing the interface between the tubular member and the preexisting structure. Alternatively, the tubular member may include a first preexpanded portion, a second preexpanded portion and an intermediate portion between the first and second preexpanded portions and including a sealing element.

The tubular member may include one or more slots provided at a preexpanded portion of the tubular member.

The axial displacement of the expansion cone relative to the expandable tubular member by pulling the expansion cone through the expandable tubular member may include applying an axial force to the expansion cone, wherein the axial force includes a substantially constant axial force and an increased axial force. The increased axial force may be provided on a periodic basis. Alternatively, the increased axial force may be provided on a random basis. The

ratio of the increased axial force to the substantially constant axial force may range from about 5 to 40%. A

Anchoring the tubular member to the preexisting structure may include heating a portion of the tubular member. Alternatively, the anchoring may include explosively anchoring the tubular member to the preexisting structure.

A resilient anchor may be placed within the preexisting structure, in which case the anchoring may include releasing the resilient anchor.

Alternatively, the anchoring may include pivoting one or more engagement elements on an anchor placed within preexisting structure. The pivoting of the engagement elements may be by, for example, actuating the engagement elements, placing a quantity of a fluidic material onto the engagement elements or displacing the expandable tubular member.

Alternatively, the anchoring may be by placing a quantity of a fluidic material onto the expandable tubular member. The fluidic material may comprise, for example, a barite plug or a flex plug.

Alternatively again, the anchoring may be by injecting a quantity of a hardenable fluidic material into the preexisting structure and at least partially curing the hardenable fluidic sealing material.

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Brief Description of the Drawings

Apparatus and methods in accordance with the invention, and other apparatus and methods, will now be described by way of example only, with reference to the accompanying drawings, in which:

FIG. 1a is a fragmentary cross-sectional illustration of the placement of an embodiment of an apparatus for expanding a tubular member within a wellbore casing.

FIG. 1b is a fragmentary cross-sectional illustration of the apparatus of FIG. 1a after anchoring the expandable tubular member of the apparatus to the wellbore casing.

FIG. 1c is a fragmentary cross-sectional illustration of the apparatus of FIG. 1b after initiating the axial displacement of the expansion cone.

FIG. 1d is a fragmentary cross-sectional illustration of the apparatus of FIG. 1b after initiating the axial displacement of the expansion cone by pulling on the expansion cone and injecting a pressurized fluid below the expansion cone.

FIG. 1e is a fragmentary cross-sectional illustration of the apparatus of FIGS. 1c and 1d after the completion of the radial expansion of the expandable tubular member.

FIG. 1f is a fragmentary cross-sectional illustration of the apparatus of FIG. 1e after the decoupling of the anchoring device of the apparatus from the wellbore casing.

FIG. 1g is a fragmentary cross-sectional illustration of the apparatus of FIG. 1f after the removal of the anchoring device of the apparatus from the wellbore casing.

135. The first support member 120 is preferably adapted to convey pressurized fluidic materials and/or electrical current and/or communication signals from a surface location to the anchoring device 135. The first support member 120 may, for example, be conventional commercially available slick wire, braided wire, coiled tubing, or drilling stock material.

The second support member 125 is preferably adapted to be coupled to a surface location. The second support member 125 is further coupled to the expansion cone 130. The second support member 125 is preferably adapted to permit the expansion cone 130 to be axially displaced relative to the first support member 120. The second support member 125 may, for example, be conventional commercially available slick wire, braided wire, coiled tubing, or drilling stock material.

The expansion cone 130 is coupled to the second support member 125. The expansion cone 130 is preferably adapted to radially expand the expandable tubular member 140 when the expansion cone 130 is axially displaced relative to the expandable tubular member 140. In a preferred embodiment, the expansion cone 130 is provided substantially as disclosed in one or more of the following: (1) U.S. Patent No. 6497289 and Australian Patent No. 767364; (2) Australian Patent No. 770008; (3) Australian Patent No. 771884; (4) U.S. Patent No. 6,328,113; (5) U.S. Patent No. 6,640,903; (6) U.S. Patent No. 6,568,471; (7) U.S. Patent No. 6,575,240; (8) U.S. Patent No. 6,557,640 and Australian Patent No. 773168; (9) U.S. Patent No. 6,604,763 and filed as AU 37920/00; and (10) Australian Patent No. 776580, the disclosures of which are incorporated herein by reference.

The anchoring device 135 is coupled to the first support member 120. The anchoring device 135 is preferably adapted to be controllably coupled to the expandable tubular member 140 and the wellbore casing 100. In this manner, the anchoring device 135 preferably controllably anchors the expandable tubular member 140 to the wellbore casing 100 to facilitate the radial expansion of the expandable tubular member 140 by the axial displacement of the expansion cone 130. In a preferred embodiment, the anchoring device 135 includes one or more expandable elements 150 that are adapted to controllably extend from the body of the anchoring device 135 to engage both the expandable tubular member 140 and

the wellbore casing 100. In a preferred embodiment, the expandable elements 150 are actuated using fluidic pressure. In a preferred embodiment, the anchoring device 135 is any one of the hydraulically actuated packers commercially available from Halliburton Energy Services or Baker-Hughes.

The expandable tubular member 140 is removably coupled to the expansion cone 130. The expandable tubular member 140 is further preferably adapted to be removably coupled to the expandable element 150 of the anchoring device 135. In a preferred embodiment, the expandable tubular member 140 includes one or more anchoring windows 155 for permitting the expandable elements 150 of the anchoring device 135 to engage the wellbore casing 100 and the expandable tubular member 140.

In a preferred embodiment, the expandable tubular member 140 further includes a lower section 160, an intermediate section 165, and an upper section 170. In a preferred embodiment, the lower section 160 includes the anchoring windows 155 in order to provide anchoring at an end portion of the expandable tubular member 140. In a preferred embodiment, the wall thickness of the lower and intermediate sections, 160 and 165, are less than the wall thickness of the upper section 170 in order to optimally couple the radially expanded portion of the expandable tubular member 140 to the wellbore casing 100.

In a preferred embodiment, the expandable tubular member 140 is further provided substantially as disclosed in one or more of the above U.S. and Australian patent disclosures.

The sealing members 145 are coupled to the outer surface of the upper portion 170 of the expandable tubular member 140. The sealing members 145 are preferably adapted to engage and fluidicly seal the interface between the radially expanded expandable tubular member 140 and the wellbore casing 100. In a preferred embodiment, the apparatus 115 includes a plurality of sealing members 145. In a preferred embodiment, the sealing members 145 surround and isolate the opening 110.

As illustrated in FIG. 1a, the apparatus 115 is preferably positioned within the wellbore casing 100 with the expandable tubular member 140 positioned in opposing relation to the opening 110. In a preferred embodiment, the apparatus

115 includes a plurality of sealing members 145 that are positioned above and below the opening 110. In this manner, the radial expansion of the expandable tubular member 140 optimally fluidicly isolates the opening 110.

As illustrated in FIG. 1b, the apparatus 115 is then anchored to the wellbore casing 100 using the anchoring device 135. In a preferred embodiment, the anchoring device 135 is pressurized and the expandable element 150 is extended from the anchoring device 135 through the corresponding anchoring window 155 in the expandable tubular member 140 into intimate contact with the wellbore casing 100. In this manner, the lower section 160 of the expandable tubular member 140 is removably coupled to the wellbore casing 100.

In an alternative embodiment, a compressible cement and/or epoxy is then injected into the annular space between the unexpanded portion of the tubular

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manner, the open hole wellbore section 205 is provided with a cased portion. More generally, the apparatus 215 is preferably utilized to form or repair wellbore casings, pipelines, or structural supports.

The apparatus 215 preferably includes a first support member 220, a second support member 225, an expansion cone 230, an anchoring device 235, an expandable tubular member 240, one or more upper sealing members 245, one or more lower sealing members 250, and a flexible coupling element 255.

The first support member 220 is preferably adapted to be coupled to a surface location. The first support member 220 is further coupled to the anchoring device 235. The first support member 220 is preferably adapted to convey pressurized fluidic materials and/or electrical current and/or communication signals from a surface location to the anchoring device 235. The first support member 220 may, for example, be conventional commercially available slick wire, braided wire, coiled tubing, or drilling stock material.

The second support member 225 is preferably adapted to be coupled to a surface location. The second support member 225 is further coupled to the expansion cone 230. The second support member 225 is preferably adapted to permit the expansion cone 230 to be axially displaced relative to the first support member 220. The second support member 225 may, for example, be conventional commercially available slick wire, braided wire, coiled tubing, or drilling stock material.

In an alternative embodiment, the support member 220 is telescopically coupled to the support member 225, and the support member 225 is coupled to a surface support structure.

The expansion cone 230 is coupled to the second support member 225. The expansion cone 230 is preferably adapted to radially expand the expandable tubular member 240 when the expansion cone 230 is axially displaced relative to the expandable tubular member 240. In a preferred embodiment, the expansion cone 230 is provided substantially as disclosed in one or more of the above U.S. and Australian patent disclosures.

The anchoring device 235 is coupled to the first support member 220. The anchoring device 235 is preferably adapted to be controllably coupled to the

expandable tubular member 240 and the open hole wellbore section 205. In this manner, the anchoring device 235 preferably controllably anchors the expandable tubular member 240 to the open hole wellbore section 205 to facilitate the radial expansion of the expandable tubular member 240 by the axial displacement of the expansion cone 230. In a preferred embodiment, the anchoring device 235 includes one or more expandable elements 260 that are adapted to controllably extend from the body of the anchoring device 235 to engage both the flexible coupling element 255 and the open hole wellbore section 205. In a preferred embodiment, the expandable elements 260 are actuated using fluidic pressure. In a preferred embodiment, the anchoring device 235 is any one of the hydraulically actuated packers commercially available from Halliburton Energy Services or Baker-Hughes.

The expandable tubular member 240 is removably coupled to the expansion cone 230. The expandable tubular member 240 is further preferably coupled to the flexible coupling element 255.

In a preferred embodiment, the expandable tubular member 240 further includes a lower section 265, an intermediate section 270, and an upper section 275. In a preferred embodiment, the lower section 265 is coupled to the flexible coupling element 255 in order to provide anchoring at an end portion of the expandable tubular member 240. In a preferred embodiment, the wall thickness of the lower and intermediate sections, 265 and 270, are less than the wall thickness of the upper section 275 in order to optimally couple the radially expanded portion of the expandable tubular member 240 to the wellbore casing 200 and the open hole wellbore section 205.

In a preferred embodiment, the expandable tubular member 240 is further provided substantially as disclosed in one or more of the above U.S. and Australian patent disclosures.

The upper sealing members 245 are coupled to the outer surface of the upper portion 275 of the expandable tubular member 240. The upper sealing members 245 are preferably adapted to engage and fluidicly seal the interface between the radially expanded expandable tubular member 240 and the wellbore

casing 200. In a preferred embodiment, the apparatus 215 includes a plurality of upper sealing members 245.

The lower sealing members 250 are coupled to the outer surface of the upper portion 275 of the expandable tubular member 240. The lower sealing members 250 are preferably adapted to engage and fluidicly seal the interface between the radially expanded expandable tubular member 240 and the open wellbore section 205. In a preferred embodiment, the apparatus 215 includes a plurality of lower sealing members 250.

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the anchoring device 330. The support member 320 is preferably adapted to convey pressurized fluidic materials and/or electrical current and/or communication signals from a surface location to the anchoring device 330. The support member 320 may, for example, be conventional commercially available slick wire, braided wire, coiled tubing, or drilling stock material.

The expansion cone 325 is coupled to the support member 320. The expansion cone 325 is preferably adapted to radially expand the expandable tubular member 335 when the expansion cone 325 is axially displaced relative to the expandable tubular member 335. In a preferred embodiment, the expansion cone 325 is provided substantially as disclosed in one or more of the above U.S. and Australian patent disclosures.

The anchoring device 330 is coupled to the support member 320 and the expansion cone 325. The anchoring device 335 is preferably adapted to controllably coupled to the expandable tubular member 335 to the wellbore casing 300. In this manner, the anchoring device 330 preferably controllably anchors the expandable tubular member 335 to the wellbore casing 300 to facilitate the radial expansion of the expandable tubular member 335 by the axial displacement of the expansion cone 325. In a preferred embodiment, the anchoring device 330 includes one or more expandable elements 345 that are adapted to controllably extend from the body of the anchoring device 330 to radially displace corresponding engagement elements 350 provided in the expandable tubular member 335. In a preferred embodiment, the radial displacement of the engagement elements 350 couples the expandable tubular member 335 to the wellbore casing 300. In a preferred embodiment, the expandable elements 345 are pistons that are actuated using fluidic pressure. In a preferred embodiment, the anchoring device 330 is any one of the hydraulically actuated anchoring devices commercially available from Halliburton Energy Services or Baker-Hughes.

In an alternative embodiment, the expandable elements 345 are explosive devices that controllably generate a radially directed explosive force for radially displacing the engagement elements 350. In a preferred embodiment, the

explosive expandable elements 345 are shaped explosive charges commercially available from Halliburton Energy Services.

The expandable tubular member 335 is removably coupled to the expansion cone 325. In a preferred embodiment, the expandable tubular member 335 includes one or more engagement devices 350 that are adapted to be radially displaced by the anchoring device 330 into engagement with the walls of the wellbore casing 300. In this manner, the expandable tubular member 335 is coupled to the wellbore casing 300. In a preferred embodiment, the engagement devices 350 include teeth for biting into the surface of the wellbore casing 100.

In a preferred embodiment, the expandable tubular member 335 further includes a lower section 355, an intermediate section 360, and an upper section 365. In a preferred embodiment, the lower section 355 includes the engagement device 350 in order to provide anchoring at an end portion of the expandable tubular member 335. In a preferred embodiment, the wall thickness of the lower and intermediate sections, 355 and 360, are less than the wall thickness of the upper section 365 in order to optimally couple the radially expanded portion of the expandable tubular member 335 to the wellbore casing 300.

In a preferred embodiment, the expandable tubular member 335 is further provided substantially as disclosed in one or more of the above U.S. and Australian patent disclosures.

The sealing members 340 are coupled to the outer surface of the upper portion 365 of the expandable tubular member 335. The sealing members 340 are preferably adapted to engage and fluidicly seal the interface between the radially expanded expandable tubular member 335 and the wellbore casing 300. In a preferred embodiment, the apparatus 315 includes a plurality of sealing members 340. In a preferred embodiment, the sealing members 340 surround and isolate the opening 310.

As illustrated in FIG. 3a, the apparatus 315 is preferably positioned within the wellbore casing 300 with the expandable tubular member 335 positioned in opposing relation to the opening 310. In a preferred embodiment, the apparatus 315 includes a plurality of sealing members 340 that are positioned above and

below the opening 310. In this manner, the radial expansion of the expandable tubular member 335 optimally fluidicly isolates the opening 310.

As illustrated in FIG. 3b, the expandable tubular member 335 of the apparatus 315 is then anchored to the wellbore casing 300 using the anchoring device 330. In a preferred embodiment, the anchoring device 330 is pressurized and the expandable element 345 is extended from the anchoring device 330 and radially displaces the corresponding engagement elements 350 of the expandable tubular member 335 into intimate contact with the wellbore casing 300. In this manner, the

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The second support member 1025 is preferably adapted to be coupled to a surface location. The second support member 1025 is further coupled to the expansion cone 1030. The second support member 1025 is preferably adapted to permit the expansion cone 1030 to be axially displaced relative to the first support member 1020. The second support member 1025 may, for example, be conventional commercially available slick wire, braided wire, coiled tubing, or drilling stock material.

In an alternative embodiment, the support member 1020 is telescopically coupled to the support member 1025, and the support member 1025 is coupled to a surface support member.

The expansion cone 1030 is coupled to the second support member 1025. The expansion cone 1030 is preferably adapted to radially expand the expandable tubular member 1040 when the expansion cone 1030 is axially displaced relative to the expandable tubular member 1040. In a preferred embodiment, the expansion cone 1030 is provided substantially as disclosed in one or more of the above U.S. and Australian patent disclosures.

The anchoring device 1035 is coupled to the first support member 1020. The anchoring device 1035 is preferably adapted to be controllably coupled to the expandable tubular member 1040 and the open hole wellbore section 1005. In this manner, the anchoring device 1035 preferably controllably anchors the expandable tubular member 1040 to the open hole wellbore section 1005 to facilitate the radial expansion of the expandable tubular member 1040 by the axial displacement of the expansion cone 1030.

In a preferred embodiment, the anchoring device 1035 includes one or more expandable elements 1060 that are adapted to controllably extend from the body of the anchoring device 1035 to engage both the flexible coupling element 1055 and the open hole wellbore section 1005. In a preferred embodiment, the expandable elements 1060 are actuated using fluidic pressure.

In a preferred embodiment, the anchoring device 1035 further includes a fluid passage 1036 adapted to receive a ball plug or other similar valving element. In this manner, fluidic materials can be exhausted from the anchoring device 1035 and the fluid passage 1036 can be controllably plugged. In a preferred

embodiment, the anchoring device 1035 is any one of the hydraulically actuated packers commercially available from Halliburton Energy Services or Baker-Hughes, modified in accordance with the teachings of the present disclosure.

In a preferred embodiment, the anchoring devices 135, 235, and 330 are also modified to includes a fluid passage that can be controllably plugged in order to permit fluidic materials to be exhausted from the anchoring devices 135, 235, and 330.

The expandable tubular member 1040 is removably coupled to the expansion cone 1030. The expandable tubular member 1040 is further preferably coupled to the flexible coupling element 1055.

In a preferred embodiment, the expandable tubular member 1040 further includes a lower section 1065, an intermediate section 1070, and an upper section 1075. In a preferred embodiment, the lower section 1065 is coupled to the flexible coupling element 1055 in order to provide anchoring at an end portion of the expandable tubular member 1040. In a preferred embodiment, the wall thickness of the lower and intermediate sections, 1065 and 1070, are less than the wall thickness of the upper section 1075 in order to optimally couple the radially expanded portion of the expandable tubular member 1040 to the wellbore casing 1000 and the open hole wellbore section 1005.

In a preferred embodiment, the expandable tubular member 1040 is further provided substantially as disclosed in one or more of the above U.S. and Australian patent disclosures.

In a preferred embodiment, the expandable tubular member 1040 is further provided in accordance with the teachings of embodiments of expandable tubular members described above and illustrated in FIGS. 5-8.

The upper sealing members 1045 are coupled to the outer surface of the upper portion 1075 of the expandable tubular member 1040. The upper sealing members 1045 are preferably adapted to engage and fluidicly seal the interface between the radially expanded expandable tubular member 1040 and the wellbore casing 1000. In a preferred embodiment, the apparatus 1015 includes a plurality of upper sealing members 1045.

The lower sealing members 1050 are coupled to the outer surface of the upper portion 1075 of the expandable tubular member 1040. The lower sealing members 1050 are preferably adapted to engage and fluidicly seal the interface between the radially expanded expandable tubular member 1040 and the open wellbore section 1005. In a preferred embodiment, the apparatus 1015 includes a plurality of lower sealing members 1050.

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The second support member 1125 is preferably adapted to be coupled to a surface location. The second support member 1125 is further coupled to the expansion cone 1130. The second support member 1125 is preferably adapted to permit the expansion cone 1130 to be axially displaced relative to the first support member 1120. The second support member 1125 may, for example, be conventional commercially available slick wire, braided wire, coiled tubing, or drilling stock material.

In a preferred embodiment, the first support member 1120 is coupled to a surface location by a slip joint and/or sliding sleeve apparatus that is concentrically coupled to the second support member 1125.

The expansion cone 1130 is coupled to the second support member 1125. The expansion cone 1130 is preferably adapted to radially expand the expandable tubular member 1140 when the expansion cone 1130 is axially displaced relative to the expandable tubular member 1140. In a preferred embodiment, the expansion cone 1130 is provided substantially as disclosed in one or more of the above U.S. and Australian patent disclosures.

The anchoring device 1135 is coupled to the first support member 1120. The anchoring device 1135 is preferably adapted to be controllably coupled to the expandable tubular member 1140 and the wellbore casing 1100. In this manner, the anchoring device 1135 preferably controllably anchors the expandable tubular member 1140 to the wellbore casing 1100 to facilitate the radial expansion of the expandable tubular member 1140 by the axial displacement of the expansion cone 1130. In a preferred embodiment, the anchoring device 1135 includes one or more expandable elements 1150 that are adapted to controllably extend from the body of the anchoring device 1135 to engage both the expandable tubular member 1140 and the wellbore casing 1100. In a preferred embodiment, the expandable elements 1150 are actuated using fluidic pressure. In a preferred embodiment, the anchoring device 1135 is any one of the hydraulically actuated packers commercially available from Halliburton Energy Services or Baker-Hughes modified in accordance with the teachings of the present disclosure.

The expandable tubular member 1140 is removably coupled to the expansion cone 1130. The expandable tubular member 1140 is further preferably

adapted to be removably coupled to the expandable elements 1150 of the anchoring device 1135. In a preferred embodiment, the expandable tubular member 1140 includes one or more anchoring windows 1155 for permitting the expandable elements 1150 of the anchoring device 1135 to engage the wellbore casing 1100 and the expandable tubular member 1140.

In a preferred embodiment, the expandable tubular member 1140 further includes a lower section 1160, an intermediate section 1165, and an upper section 1170. In a preferred embodiment, the lower section 1160 rests upon and is supported by the expansion cone 1130. In a preferred embodiment, the intermediate section 1165 includes the anchoring windows 1155 in order to provide anchoring at an intermediate portion of the expandable tubular member 1140.

In a preferred embodiment, the expandable tubular member 1140 is further provided substantially as disclosed in one or more of the above U.S. and Australian patent disclosures.

The sealing members 1145 are coupled to the outer surface of the expandable tubular member 1140. The sealing members 1145 are preferably adapted to engage and fluidicly seal the interface between the radially expanded expandable tubular member 1140 and the wellbore casing 1100. In a preferred embodiment, the apparatus 1115 includes a plurality of sealing members 1145. In a preferred embodiment, the sealing members 1145 surround and isolate the opening 1110.

As illustrated in FIG. 11a, the apparatus 1115 is preferably positioned within the wellbore casing 1100 with the expandable tubular member 1140 positioned in opposing relation to the opening 1110. In a preferred embodiment, the apparatus 1115 includes a plurality of sealing members 1145 that are positioned above and below the opening 1110. In this manner, the radial expansion of the expandable tubular member 1140 optimally fluidicly isolates the opening 1110.

As illustrated in FIG. 11b, the apparatus 1115 is then anchored to the wellbore casing 1100 using the anchoring device 1135. In a preferred embodiment, the anchoring device 1135 is pressurized and the expandable element 1150 is extended from the anchoring device 1135 through the

corresponding anchoring window 1155 in the expandable tubular member 1140 into intimate contact with the wellbore casing 1100. In this manner, the intermediate section 1165 of the expandable tubular member 1140 is removably coupled to the wellbore casing 1100.

In an alternative embodiment, a compressible cement and/or epoxy is then injected into at least a portion of the annular space between the unexpanded portion of the tubular member 1140 and the wellbore casing 1100. The compressible cement and/or epoxy is then permitted to at least partially cure prior to the initiation of the

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the result of unintentional damage to the wellbore casing 1200, or due to a prior perforation or fracturing operation performed upon the surrounding subterranean formation 1205. As will be recognized by persons having ordinary skill in the art, the openings 1210 can adversely affect the subsequent operation and use of the wellbore casing 1200 unless they are sealed off.

In a preferred embodiment, an apparatus 1215 is utilized to seal off the openings 1210 in the wellbore casing 1200. More generally, the apparatus 1215 is preferably utilized to form or repair wellbore casings, pipelines, or structural supports.

The apparatus 1215 preferably includes a support member 1220, an expandable expansion cone 1225, an expandable tubular member 1235, and one or more sealing members 1240.

The support member 1220 is preferably adapted to be coupled to a surface location. The support member 1220 is further coupled to the expandable expansion cone 1225. The support member 320 is preferably adapted to convey pressurized fluidic materials and/or electrical current and/or communication signals from a surface location to the expandable expansion cone. The support member 1220 may, for example, be conventional commercially available slick wire, braided wire, coiled tubing, or drilling stock material.

The expandable expansion cone 1225 is coupled to the support member 1220. The expandable expansion cone 1225 is preferably adapted to radially expand the expandable tubular member 1235 when the expandable expansion cone 1225 is axially displaced relative to the expandable tubular member 1235. The expandable expansion cone 1225 is further preferably adapted to radially expand at least a portion of the expandable tubular member 1235 when the expandable expansion cone 1225 is controllably radially expanded. The expandable expansion cone 1225 may be any number of conventional commercially available radially expandable expansion cones. In a preferred embodiment, the expandable expansion cone 1225 is provided substantially as disclosed in U.S. Patent No. 5,348,095, the disclosure of which is incorporated herein by reference.

In a preferred embodiment, the expansion cone 1225 is further provided substantially as disclosed in one or more of the above U.S. and Australian patent disclosures.

The expandable tubular member 1235 is removably coupled to the expansion cone 1225. In a preferred embodiment, the expandable tubular member 1235 includes one or more engagement devices 1250 that are adapted to couple with and penetrate the wellbore casing 1200. In this manner, the expandable tubular member 1235 is optimally coupled to the wellbore casing 1200. In a preferred embodiment, the engagement devices 1250 include teeth for biting into the surface of the wellbore casing 1200.

In a preferred embodiment, the expandable tubular member 1235 further includes a lower section 1255, an intermediate section 1260, and an upper section 1265. In a preferred embodiment, the lower section 1255 includes the engagement devices 1250 in order to provide anchoring at an end portion of the expandable tubular member 1235. In a preferred embodiment, the wall thickness of the lower and intermediate sections, 1255 and 1260, are less than the wall thickness of the upper section 1265 in order to optimally faciliate the radial expansion of the lower and intermediate sections, 1255 and 1260, of the expandable tubular member 1235. In an alternative embodiment, the lower section 1255 of the expandable tubular member 1235 is slotted in order to optimally facilitate the radial expansion of the lower section 1255 of the expandable tubular member 1235 using the expandable expansion cone 1225.

In a preferred embodiment, the expandable tubular member 1235 is further provided substantially as disclosed in one or more of the above U.S. and Australian patent disclosures.

The sealing members 1240 are preferably coupled to the outer surface of the upper portion 1265 of the expandable tubular member 1235. The sealing members 1240 are preferably adapted to engage and fluidicly seal the interface between the radially expanded expandable tubular member 1235 and the wellbore casing 1200. In a preferred embodiment, the apparatus 1215 includes a plurality of sealing members 1240. In a preferred embodiment, the sealing members 1240 surround and isolate the opening 1210.

As illustrated in FIG. 12a, the apparatus 1215 is preferably positioned within the wellbore casing 1200 with the expandable tubular member 1235 positioned in opposing relation to the opening 1210. In a preferred embodiment, the apparatus 1215 includes a plurality of sealing members 1240 that are positioned above and below the opening 1210. In this manner, the radial expansion of the expandable tubular member 1235 optimally fluidicly isolates the opening 1210.

As illustrated in FIG. 12b, the expandable tubular member 1235 of the apparatus 1215 is then anchored to the wellbore casing 1200 by expanding the

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In a preferred embodiment, an apparatus 1315 is utilized to seal off the openings 1310 in the wellbore casing 1300. More generally, the apparatus 1315 is preferably utilized to form or repair wellbore casings, pipelines, or structural supports.

The apparatus 1315 preferably includes a support member 1320, an expansion cone 1325, an expandable tubular member 1335, a heater 1340, and one or more sealing members 1345.

The support member 1320 is preferably adapted to be coupled to a surface location. The support member 1320 is further coupled to the expansion cone 1325. The support member 1320 is preferably adapted to convey pressurized fluidic materials and/or electrical current and/or communication signals from a surface location to the expansion cone 1325 and heater 1340. The support member 1320 may, for example, be conventional commercially available slick wire, braided wire, coiled tubing, or drilling stock material.

The expansion cone 1325 is coupled to the support member 1320. The expansion cone 1325 is preferably adapted to radially expand the expandable tubular member 1335 when the expansion cone 1325 is axially displaced relative to the expandable tubular member 1335. The expansion cone 1325 may be any number of conventional commercially available expansion cones.

In a preferred embodiment, the expansion cone 1325 is further provided substantially as disclosed in one or more of the above U.S. and Australian patent disclosures.

The expandable tubular member 1335 is removably coupled to the expansion cone 1325. In a preferred embodiment, the expandable tubular member 1335 includes one or more engagement devices 1350 that are adapted to couple with and penetrate the wellbore casing 1300. In this manner, the expandable tubular member 1335 is optimally coupled to the wellbore casing 1300. In a preferred embodiment, the engagement devices 1350 include teeth for biting into the surface of the wellbore casing 1300.

In a preferred embodiment, the expandable tubular member 1335 further includes a lower section 1355, an intermediate section 1360, and an upper section 1365. In a preferred embodiment, the lower section 1355 includes the

engagement devices 1350 in order to provide anchoring at an end portion of the expandable tubular member 1335. In a preferred embodiment, the wall thickness of the lower and intermediate sections, 1355 and 1360, are less than the wall thickness of the upper section 1365 in order to optimally faciliate the radial expansion of the lower and intermediate sections, 1355 and 1360, of the expandable tubular member 1335.

In a preferred embodiment, the lower section 1355 of the expandable tubular member 1335 includes one or more shape memory metal inserts 1370. In a preferred embodiment, the inserts 1370 are adapted to radially expand the lower section 1355 of the expandable tubular member 1335 into intimate contact with the wellbore casing 1300 when heated by the heater 1340. The shape memory metal inserts 1370 may be fabricated from any number of conventional commercially available shape memory alloys such as, for example, NiTi or NiTiNOL using conventional forming processes such as, for example, those described in U.S. Patent Nos. 5,312,152, 5,344,506, and 5,718,531, the disclosures of which are incorporated herein by reference. In this manner, the shape memory metal inserts 1370 preferably radially expand the lower section 1355 of the expandable tubular member 1335 when the inserts 1370 are heated to a temperature above their transformation temperature using the heater 1340. In a preferred embodiment, the transformation temperature of the inserts 1370 ranges from about 250° F to 450° F. In a preferred embodiment, the material composition of the lower section 1355 of the expandable tubular member 1335 is further selected to maximize the radial expansion of the lower section 1355 during the transformation process.

In a preferred embodiment, the inserts 1370 are positioned within one or more corresponding recesses 1375 provided in the lower section 1355 of the expandable tubular member 1335. Alternatively, the inserts 1370 are completely contained within the lower section 1355 of the expandable tubular member 1335.

In a preferred embodiment, the expandable tubular member 1335 is further provided substantially as disclosed in one or more of the above U.S. and Australian patent disclosures.

The heater 1340 is coupled to the support member 1320. The heater 1340 is preferably adapted to controllably generate a localized heat source for elevating

the temperature of the inserts 1370. In a preferred embodiment, the heater 1340 includes a conventional thermostat control in order to control the operating temperature. The heater 1340 is preferably controlled by a surface control device in a conventional manner.

The sealing members 1345 are preferably coupled to the outer surface of the upper portion 1365 of the expandable tubular member 1335. The sealing members 1345 are preferably adapted to engage and fluidicly seal the interface between the

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The coupling 1430 is coupled to the second support member 1425. The coupling 1430 is further preferably removably coupled to the expandable tubular member 1435. The coupling 1430 may be any number of conventional commercially available passive or actively controlled coupling devices such as, for example, packers or slips. In a preferred embodiment, the coupling 1430 is a mechanical slip.

The expandable tubular member 1435 is removably coupled to the coupling 1430. In a preferred embodiment, the expandable tubular member 1435 includes one or more engagement devices that are adapted to couple with and penetrate the wellbore casing 1400. In this manner, the expandable tubular member 1435 is optimally coupled to the wellbore casing 1400. In a preferred embodiment, the engagement devices include teeth for biting into the surface of the wellbore casing 1400. In a preferred embodiment, the expandable tubular member 1435 further includes one or more sealing members on the outside surface of the expandable tubular member 1435 in order to optimally seal the interface between the expandable tubular member 1435 and the wellbore casing 1400.

In a preferred embodiment, the expandable tubular member 1435 is further provided substantially as disclosed in one or more of the above U.S. and Australian patent disclosures.

The expansion cone 1440 is coupled to the first support member 1420 and the third support member 1445. The expansion cone 1440 is preferably adapted to radially expand the expandable tubular member 1435 when the expansion cone 1440 is axially displaced relative to the expandable tubular member 1435.

In a preferred embodiment, the expansion cone 1440 is provided substantially as disclosed in one or more of the above U.S. and Australian patent disclosures.

The third support member 1445 is preferably coupled to the expansion cone 1440 and the packer 1450. The third support member 1445 is preferably adapted to convey pressurized fluidic materials and/or electrical current and/or communication signals from a surface location to the packer 1450. The third support member 1445 may, for example, be conventional commercially available slick wire, braided wire, coiled tubing, or drilling stock material.

The packer 1450 is coupled to the third support member 1445. The packer 1450 is further preferably adapted to controllably coupled to the wellbore casing 1400. The packer 1450 may be any number of conventional commercially available

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further includes one or more sealing members 1545 on the outside surface of the expandable tubular member 1525 in order to optimally seal the interface between the expandable tubular member 1525 and the wellbore casing 1500.

In a preferred embodiment, the expandable tubular member 1525 includes a lower section 1550, an intermediate section 1555, and an upper section 1560. In a preferred embodiment, the wall thicknesses of the lower and intermediate sections, 1550 and 1555, are less than the wall thickness of the upper section 1560 in order to optimally facilitate the radial expansion of the expandable tubular member 1525. In a preferred embodiment, the sealing members 1545 are provided on the outside surface of the upper section 1560 of the expandable tubular member 1525. In a preferred embodiment, the resilient anchor 1540 is coupled to the lower section 1550 of the expandable tubular member 1525 in order to optimally anchor the expandable tubular member 1525 to the wellbore casing 1500.

In a preferred embodiment, the expandable tubular member 1525 is further provided substantially as disclosed in one or more of the above U.S. and Australian patent disclosures.

The expansion cone 1530 is coupled to the support member 1520 and the coupling 1535. The expansion cone 1530 is preferably adapted to radially expand the expandable tubular member 1525 when the expansion cone 1530 is axially displaced relative to the expandable tubular member 1525. The expansion cone 1530 may be any number of conventional commercially available expansion cones.

In a preferred embodiment, the expansion cone 1530 is provided substantially as disclosed in one or more of the above U.S. and Australian patent disclosures.

The coupling 1535 is preferably coupled to the support member 1520, the expansion cone 1530 and the resilient anchor 1540. The coupling 1535 is preferably adapted to convey pressurized fluidic materials and/or electrical current and/or communication signals from a surface location to the resilient anchor 1535. The coupling 1535 may, for example, be conventional commercially available slick wire, braided wire, coiled tubing, or drilling stock material. In a preferred

embodiment, the coupling 1535 is decoupled from the resilient anchor 1540 upon initiating the axial displacement of the expansion cone 1530.

The resilient anchor 1540 is preferably coupled to the lower section 1550 of the expandable tubular member 1525 and the coupling 1535. The resilient anchor

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The support member 2020 is preferably adapted to be coupled to a surface location. The support member 2020 is further coupled to the expansion cone 2030. The support member 2020 is preferably adapted to convey pressurized fluidic materials and/or electrical current and/or communication signals from a surface location to the anchor 2040. The support member 2020 may, for example, be conventional commercially available slick wire, braided wire, coiled tubing, or drilling stock material.

The expandable tubular member 2025 is removably coupled to the expansion cone 2030. In a preferred embodiment, the expandable tubular member 2025 includes one or more engagement devices that are adapted to couple with and penetrate the wellbore casing 2000. In this manner, the expandable tubular member 2025 is optimally coupled to the wellbore casing 2000. In a preferred embodiment, the engagement devices include teeth for biting into the surface of the wellbore casing 2000. In a preferred embodiment, the expandable tubular member 2025 further includes one or more sealing members 2045 on the outside surface of the expandable tubular member 2025 in order to optimally seal the interface between the expandable tubular member 2025 and the wellbore casing 2000.

In a preferred embodiment, the expandable tubular member 2025 includes a lower section 2050, an intermediate section 2055, and an upper section 2060. In a preferred embodiment, the wall thicknesses of the lower and intermediate sections, 2050 and 2055, are less than the wall thickness of the upper section 2060 in order to optimally facilitate the radial expansion of the expandable tubular member 2025. In a preferred embodiment, the sealing members 2045 are provided on the outside surface of the upper section 2060 of the expandable tubular member 2025. In a preferred embodiment, the resilient anchor 2040 is coupled to the lower section 2050 of the expandable tubular member 2025 in order to optimally anchor the expandable tubular member 2025 to the wellbore casing 2000.

In a preferred embodiment, the expandable tubular member 2025 is further provided substantially as disclosed in one or more of the above U.S. and Australian patent disclosures.

The expansion cone 2030 is preferably coupled to the support member 2020 and the coupling 2035. The expansion cone 2030 is preferably adapted to radially expand the expandable tubular member 2025 when the expansion cone 2030 is axially displaced relative to the expandable tubular member 2025.

In a preferred embodiment, the expansion cone 2030 is provided substantially as disclosed in one or more of the above U.S. and Australian patent disclosures.

The coupling 2035 is preferably coupled to the support member 2020, the expansion cone 2030, and the anchor 2040. The coupling 2035 is preferably adapted to convey pressurized fluidic materials and/or electrical current and/or communication signals from a surface location to the anchor 2035. The coupling 2035 may, for example, be conventional commercially available slick wire, braided wire, coiled tubing, or drilling stock material. In a preferred embodiment, the coupling 2035 is decoupled from the anchor 2040 upon initiating the axial displacement of the expansion cone 2030.

The anchor 2040 is preferably coupled to the lower section 2050 of the expandable tubular member 2025 and the coupling 2035. The anchor 2040 is further preferably adapted to be controllably coupled to the wellbore casing 2000.

Referring to FIGS. 21a and 21b, in a preferred embodiment, the anchor 2040 includes a housing 2100, one or more spikes 2105, and one or more corresponding actuators 2110. In a preferred embodiment, the spikes 2105 are outwardly extended by the corresponding actuators 2110. In an alternative embodiment, the spikes 2105 are outwardly actuated by displacing the apparatus 2015 upwardly. In another alternative embodiment, the spikes 2105 are outwardly extended by placing a quantity of fluidic material onto the spikes 2105.

The housing 2100 is coupled to the lower section 2050 of the expandable tubular member 2025, the spikes 2105, and the actuators 2110. The housing 2100 is further preferably coupled to the coupling 2035. In a preferred embodiment, the housing 2100 is adapted to convey electrical, communication, and/or hydraulic signals from the coupling 2035 to the actuators 2110.
The spikes 2105 are preferably movably coupled to the housing 2100 and the corresponding actuators 2110. The spikes 2105 are preferably adapted to pivot

relative to the housing 2100. The spikes 2105 are further preferably adapted to extend outwardly in a radial direction to engage, and at least partially penetrate, the wellbore casing 2000, or other preexisting structure such as, for example, the wellbore. Each of the spikes 2105 further preferably include a concave upwardly facing surface 2115. In a preferred embodiment, the placement of a quantity of fluidic material such as, for example, a barite plug or a flex plug, onto the surfaces 2115 causes the spikes 2105 to pivot outwardly away from the housing 2100 to engage the wellbore casing 2000, or other preexisting structure such as, for example, the wellbore. Alternatively, the upward displacement of the apparatus 2015 causes the spikes 2105 to pivot outwardly away from the housing 2100 to

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In a preferred embodiment, the expandable tubular member 2025 further includes a lower section 2350, an intermediate section 2355, and an upper section 2360. In a preferred embodiment, the wall thicknesses of the lower and intermediate sections, 2350 and 2355, are less than the wall thickness of the upper section 2360 in order to optimally facilitate the radial expansion of the expandable tubular member 2330. In a preferred embodiment, the lower section 2350 of the expandable tubular member 2330 includes one or more slots 2365 adapted to permit a fluidic sealing material to penetrate the lower section 2350.

In a preferred embodiment, the expandable tubular member 2330 is further provided substantially as disclosed in one or more of the above U.S. and Australian patent disclosures.

The expansion cone 2335 is preferably coupled to the support member 2325. The expansion cone 2335 is further preferably removably coupled to the expandable tubular member 2330. The expansion cone 2335 is preferably adapted to radially expand the expandable tubular member 2330 when the expansion cone 2335 is axially displaced relative to the expandable tubular member 2330.

In a preferred embodiment, the expansion cone 2335 is provided substantially as disclosed in one or more of the above U.S. and Australian patent disclosures.

The upper sealing member 2340 is coupled to the outside surface of the upper section 2360 of the expandable tubular member 2330. The upper sealing member 2340 is preferably adapted to fluidicly seal the interface between the radially expanded upper section 2360 of the expandable tubular member 2330 and the wellbore casing 2300. The upper sealing member 2340 may be any number of conventional commercially available sealing members. In a preferred embodiment, the upper sealing member 2340 is a viton rubber in order to optimally provide load carrying and pressure sealing capacity.

The lower sealing member 2345 is preferably coupled to the outside surface of the upper section 2360 of the expandable tubular member 2330. The lower sealing member 2340 is preferably adapted to fluidicly seal the interface between the radially expanded upper section 2360 of the expandable tubular

member 2330 and the open hole wellbore section 2305. The lower sealing member 2345 may be any number of conventional commercially available sealing members. In a preferred embodiment, the lower sealing member 2345 is viton rubber in order to optimally provide load carrying and sealing capacity.

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The expansion cone 2435 is preferably coupled to the support member 2425 and the coupling 2440. The expansion cone 2435 is further preferably removably coupled to the expandable tubular member 2430. The expansion cone 2435 is preferably adapted to radially expand the expandable tubular member 2430 when the expansion cone 2435 is axially displaced relative to the expandable tubular member 2430.

In a preferred embodiment, the expansion cone 2435 is provided substantially as disclosed in one or more of the above U.S. and Australian patent disclosures.

The coupling 2440 is preferably coupled to the support member 2425 and the expansion cone 2435. The coupling 2440 is preferably adapted to convey electrical, communication, and/or hydraulic signals to and/or from the packer 2445. The coupling 2440 may be any number of conventional support members such as, for example, commercially available slick wire, braided wire, coiled tubing, or drilling stock material.

The packer 2445 is coupled to the coupling 2440. The packer 2445 is further removably coupled to the lower section 2465 of the expandable wellbore casing 2430. The packer 2445 is preferably adapted to provide sufficient frictional force to support the lower section 2465 of the expandable wellbore casing 2430 and the mass 2450. The packer 2445 may be any number of conventional commercially available packers. In a preferred embodiment, the packer 2445 is an RTTS packer available from Halliburton Energy Services in order to optimally provide multiple sets and releases. In an alternative embodiment, hydraulic slips may be substituted for, or used to supplement, the packer 2445.

The mass 2450 is preferably coupled to the lower section 2465 of the expandable tubular member 2430. The mass 2450 is preferably selected to provide a tensile load on the lower section 2465 of the expandable tubular member 2430 that ranges from about 50 to 100 % of the yield point of the upper section 2475 of the expandable tubular member 2430. In this manner, when the packer 2445 is released, the axial force provided by the mass 2450 optimally radially expands and extrudes the expandable tubular member 2430 off of the expansion cone 2435.

The upper sealing member 2455 is preferably coupled to the outside surface of the upper section 2475 of the expandable tubular member 2430. The upper sealing member 2455 is preferably adapted to fluidicly seal the interface between the radially expanded upper section 2475 of the expandable tubular member 2430 and

The expandable tubular member 2530 is removably coupled to the expansion cone 2535. In a preferred embodiment, the expandable tubular member 2530 further includes one or more upper and lower sealing members, 2555 and 2560, on the outside surface of the expandable tubular member 2530 in order to optimally seal the interface between the expandable tubular member 2530 and the wellbore casing 2500 and the open hole wellbore section 2505.

In a preferred embodiment, the expandable tubular member 2530 further includes a lower section 2565, an intermediate section 2570, and an upper section 2530. In a preferred embodiment, the wall thicknesses of the lower and intermediate sections, 2565 and 2570, are less than the wall thickness of the upper section 2575 in order to optimally facilitate the radial expansion of the expandable tubular member 2530.

In a preferred embodiment, the lower section 2565 of the expandable tubular member 2530 further includes the chamber 2540 and the end plate 2545.

In a preferred embodiment, the expandable tubular member 2530 is further provided substantially as disclosed in one or more of the above U.S. and Australian patent disclosures.

The expansion cone 2535 is preferably coupled to the support member 2525. The expansion cone 2535 is further preferably removably coupled to the expandable tubular member 2530. The expansion cone 2535 is preferably adapted to radially expand the expandable tubular member 2530 when the expansion cone 2535 is axially displaced relative to the expandable tubular member 2530. The expansion cone 2535 is further preferably adapted to convey fluidic materials to and/or from the chamber 2540.

In a preferred embodiment, the expansion cone 2535 is provided substantially as disclosed in one or more of the above U.S. and Australian patent disclosures.

The chamber 2540 is defined by the interior portion of the lower section 2565 of the expandable tubular member 2530 below the expansion cone 2535 and above the end plate 2545. The chamber 2540 is preferably adapted to contain a quantity of a fluidic materials having a higher density than the fluidic materials outside of the expandable tubular member 2530.

The upper sealing member 2555 is preferably coupled to the outside surface of the upper section 2575 of the expandable tubular member 2530. The upper sealing member 2555 is preferably adapted to fluidicly seal the interface between the

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embodiment, the preexisting structure includes a pipeline. In a preferred embodiment, the preexisting structure includes a structural support.

An apparatus also has been described that includes a tubular member coupled to a preexisting structure. The tubular member is coupled to the preexisting structure by the process of: positioning the tubular member and an expansion cone within the preexisting structure, axially displacing the expansion cone, removing the expansion cone, and applying direct radial pressure to the tubular member. In a preferred embodiment, axially displacing the expansion cone includes: pressurizing at least a portion of the interior of the tubular member. In a preferred embodiment, axially displacing the expansion cone includes: injecting a fluidic material into the tubular member. In a preferred embodiment, axially displacing the expansion cone includes: applying a tensile force to the expansion cone. In a preferred embodiment, axially displacing the expansion cone includes: displacing the expansion cone into the tubular member. In a preferred embodiment, axially displacing the expansion cone includes: displacing the expansion cone out of the tubular member. In a preferred embodiment, axially displacing the expansion cone radially expands the tubular member by about 10% to 20%. In a preferred embodiment, applying direct radial pressure to the tubular member radially expands the tubular member by up to about 5%. In a preferred embodiment, applying direct radial pressure to the tubular member includes applying a radial force at discrete locations. In a preferred embodiment, the preexisting structure includes a wellbore casing. In a preferred embodiment, the preexisting structure includes a pipeline. In a preferred embodiment, the preexisting structure includes a structural support.

Although this detailed description has shown and described illustrative embodiments of the invention, this description contemplates a wide range of modifications, changes, and substitutions. In some instances, one may employ some features of the present invention without a corresponding use of the other features. Accordingly, it is appropriate that readers should construe the appended claims broadly, and in a manner consistent with the scope of the invention.

Throughout this specification and the claims which follow, unless the context requires otherwise, the word "comprise", and variations such as "comprises" and "comprising", will be understood to imply the inclusion of a stated integer or step or group of integers or steps but not the exclusion of any other integer or step or group of integers or steps.

The reference to any prior art in this specification is not, and should not be taken as, an acknowledgment or any form of suggestion that that prior art forms part of the common general knowledge in Australia.

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THE CLAIMS DEFINING THE INVENTION ARE AS FOLLOWS:

1. A method of coupling an expandable tubular member to a preexisting structure, comprising:

    positioning the tubular member and an expansion cone within the preexisting structure;

    anchoring the tubular member to the preexisting structure;

    axially displacing the expansion cone relative to the tubular member by pulling the expansion cone through the tubular member; and

    lubricating the interface between the expansion cone and the tubular member.

2. The method of claim 1, wherein the lubricating includes injecting a lubricating fluid into the interface between the expansion cone and the tubular member.

3. The method of claim 2, wherein the lubricating fluid has a viscosity ranging from about 1 to 10,000 centipoise.

4. The method of claim 2 or 3, wherein the injecting includes:

    injecting lubricating fluid into a tapered end of the expansion cone.

5. The method of any one of claims 2 to 4, wherein the injecting includes: injecting lubricating fluid into an area around an axial midpoint of a first tapered end of the expansion cone.

6. The method of any one of claims 2 to 5, wherein the injecting includes: injecting lubricating fluid into a second end of the expansion cone.

7. The method of any one of claims 2 to 6, wherein the injecting includes: injecting lubricating fluid into an interior of the expansion cone.

8. The method of any one of claims 2 to 7, wherein the injecting includes: injecting lubricating fluid through an outer surface of the expansion cone.

9. The method of any one of claims 2 to 8, wherein the injecting includes: injecting the lubricating fluid into a plurality of discrete locations along a trailing edge portion of the expansion cone.

10. The method of any one of claims 2 to 9, wherein the lubricating fluid comprises:

drilling mud.

11. The method of claim 10, wherein the lubricating fluid further includes:

TorqTrim III;

EP Mudlib; and

DrillN-Slid.

12. The method of any one of claims 2 to 9, wherein the lubricating fluid comprises:

TorqTrim III;

EP Mudlib; and

DrillN-Slid.

13. The method of claim 1, wherein the lubricating comprises coating the interior surface of the tubular member with a lubricant.

14. The method of claim 13, wherein the lubricating includes:

coating the interior surface of the tubular member with a first part of a lubricant; and

applying a second part of the lubricant to the interior surface of the tubular member.

15. The method of claim 13 or 14, wherein the lubricant comprises a metallic soap.

16. The method of any one of claims 13 to 15, wherein the lubricant is selected from the group consisting of C-Lube-10, C-PHOS-58-M, and C-PHOS-58-R.

17. The method of any one of claims 13 to 16, wherein the lubricant provides a sliding friction coefficient of less than about 0.20.

18. The method of any one of claims 13 to 17, wherein the lubricant is chemically bonded to the interior surface of the tubular member.

19. The method of any one of claims 13 to 17, wherein the lubricant is mechanically bonded to the interior surface of the tubular member.

20. The method of any one of claims 13 to 17, wherein the lubricant is adhesively bonded to the interior surface of the tubular member.

21. The method of any one of claims 13 to 20, wherein the lubricant includes epoxy, molybdenum disulfide, graphite, aluminum, copper, alumisilicate and polyethylenepolyamine.

22. The method of any one of the preceding claims, wherein the tubular member includes:

an annular member, including:

a wall thickness that varies less than about 8 %;

a hoop yield strength that varies less than about 10 %;

imperfections of less than about 8 % of the wall thickness;

no failure for radial expansions of up to about 30 %; and

no necking of the walls of the annular member for radial expansions of up to about 25%.

23. The method of any one of the preceding claims, wherein the tubular member includes:

a first tubular member;

a second tubular member; and

a pin and box threaded connection for coupling the first tubular member to the second tubular member, the threaded connection including:

one or more sealing members for sealing the interface between the first and second tubular members.

24. The method of claim 23, wherein the one or more sealing members are positioned adjacent to an end portion of the threaded connection.

25. The method of claim 23, wherein there are at least two sealing members and one of the sealing members is positioned adjacent to an end portion of the threaded connection; and wherein another one of the sealing members is not positioned adjacent to an end portion of the threaded connection.

26. The method of claim 23, wherein there is a plurality of sealing members and some of them are positioned adjacent to an end portion of the threaded connection.

27. The method of any one of claims 1 to 22, wherein the tubular member includes a plurality of tubular members having threaded portions that are coupled to one another by the process of:

coating the threaded portions of the tubular members with a sealant;

coupling the threaded portions of the tubular members; and

curing the sealant.

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28. The method of claim 27, wherein the sealant is selected from epoxies, thermosetting sealing compounds, curable sealing compounds, and sealing compounds having polymerizable materials.

29. The method of claim 27 or 28, further including:

initially curing the sealant prior to radially expanding the tubular members; and

finally curing the sealant after radially expanding the tubular members.

30. The method of any one of claims 27 to 29, wherein the sealant can be stretched up to about 30 to 40 percent after curing without failure.

31. The method of any one of claims 27 to 30, wherein the sealant is resistant to conventional wellbore fluidic materials.

32. The method of any one of claims 27 to 31, wherein the material properties of the sealant are substantially stable for temperatures ranging from about 0 to 450°F (about –18 to 227°C).

33. The method of any one of claims 27 to 32, further including:

applying a primer to the threaded portions of the tubular members prior to coating the threaded portions of the tubular members with the sealant.

34. The method of any one of claims 27 to 32, further including:

applying a primer to the threaded portion of one of the tubular members and the sealant to the threaded portion of the other one of the tubular members.

35. The method of claim 33 or 34, wherein the primer includes a curing catalyst.

36. The method of any one of claims 1 to 22, wherein the tubular member includes:

a pair of rings for engaging the preexisting structure; and

a sealing element positioned between the rings for sealing the interface between the tubular member and the preexisting structure.

37. The method of any one of claims 1 to 22, wherein the tubular member includes:

a first preexpanded portion;

a second preexpanded portion; and

an intermediate portion between the first and second preexpanded portions and including a sealing element.

38. The method of any one of claims 1 to 22, wherein the tubular member includes one or more slots provided at a preexpanded portion of the tubular member.

39. The method of any one of the preceding claims, wherein axially displacing the expansion cone relative to the expandable tubular member by pulling the expansion cone through the expandable tubular member includes applying an axial force to the expansion cone;

wherein the axial force includes:

a substantially constant axial force; and

an increased axial force.

40. The method of claim 39, wherein the increased axial force is provided on a periodic basis.

41. The method of claim 39, wherein the increased axial force is provided on a random basis.

42. The method of any one of claims 39 to 41, wherein the ratio of the increased axial force to the substantially constant axial force ranges from about 5 to 40 %.

43. The method of any one of the preceding claims, wherein anchoring the tubular member to the preexisting structure includes heating a portion of the tubular member.

44. The method of any one of claims 1 to 42, wherein anchoring the tubular member to the preexisting structure includes explosively anchoring the tubular member to the preexisting structure.

45. The method of any one of claims 1 to 42, further comprising:
placing a resilient anchor within the preexisting structure;
wherein the anchoring includes releasing the resilient anchor.

46. The method of any one of claims 1 to 42, further comprising:
placing an anchor within the preexisting structure;
wherein the anchoring includes pivoting one or more engagement elements on the anchor.

47. The method of claim 46, wherein pivoting the engagement elements includes:
actuating the engagement elements.

48. The method of claim 46, wherein pivoting the engagement elements includes:
placing a quantity of a fluidic material onto the engagement elements.

49. The method of claim 46, wherein pivoting the engagement elements includes:
displacing the expandable tubular member.

50. The method of any one of claims 1 to 42, further comprising:
placing a quantity of a fluidic material onto the expandable tubular member to anchor the expandable tubular member to the preexisting structure.

51. The method of claim 50, wherein the fluidic material comprises a barite plug.

52. The method of claim 50, wherein the fluidic material comprises a flex plug.

53. The method of any one of claims 1 to 42, wherein anchoring the tubular member to the preexisting structure includes injecting a quantity of a hardenable fluidic material into the preexisting structure; and

at least partially curing the hardenable fluidic sealing material.

54. A method of coupling an expandable tubular member to a preexisting structure, substantially as herein described with reference to the accompanying drawings.

55. A system for coupling an expandable tubular member to a preexisting structure, comprising:

means for positioning the tubular member and an expansion cone within the preexisting structure;

means for anchoring the tubular member to the preexisting structure;

means for axially displacing the expansion cone relative to the tubular member by pulling the expansion cone through the tubular member; and

means for injecting a lubricating fluid into the trailing edge of the interface between the expansion cone and the tubular member.

56. The system of claim 55, wherein the lubricating fluid has a viscosity ranging from about 1 to 10,000 centipoise.

57. The system of claim 55 or 56, wherein the injecting includes:

injecting lubricating fluid into a tapered end of the expansion cone.

58. The system of any one of claims 55 to 57, wherein the means for injecting includes:

means for injecting lubricating fluid into the area around the axial midpoint of a first tapered end of the expansion cone.

59. The system of any one of claims 55 to 58, wherein the means for injecting includes:

means for injecting lubricating fluid into a second end of the expansion cone.

60. The system of any one of claims 55 to 59, wherein the means for injecting includes:

means for injecting lubricating fluid into an interior of the expansion cone.

61. The system of any one of claims 55 to 60, wherein the means for injecting includes:

means for injecting lubricating fluid through an outer surface of the expansion cone.

62. The system of any one of claims 55 to 61, wherein the means for injecting includes:

means for injecting the lubricating fluid into a plurality of discrete locations along the trailing edge portion of the expansion cone.

63. The system of any one of claims 55 to 62, wherein the lubricating fluid comprises:

drilling mud.

64. The system of claim 63, wherein the lubricating fluid further includes:

TorqTrim III;

EP Mudlib; and

DrillN-Slid.

65. The system of any one of claims 55 to 62, wherein the lubricating fluid comprises:

TorqTrim III;
EP Mudlib; and
DrillN-Slid.

66. A system for coupling an expandable tubular member to a preexisting structure, comprising:

means for positioning the tubular member and an expansion cone within the preexisting structure;
means for anchoring the tubular member to the preexisting structure;
means for axially displacing the expansion cone relative to the tubular member by pulling the expansion cone through the tubular member; and
means for lubricating an interface between the tubular member and the expansion cone with a lubricant.

67. The system of claim 66, wherein the means for lubricating comprises means for coating the interior surface of the tubular member with the lubricant.

68. The system of claim 67, wherein the means for lubricating the interface between the expansion cone and the tubular member includes:

means for coating the interior surface of the tubular member with a first part of a lubricant; and
means for applying a second part of the lubricant to the interior surface of the tubular member.

69. The system of claim 67 or 68, wherein the lubricant comprises a metallic soap.

70. The system of any one of claims 67 to 69, wherein the lubricant is selected from the group consisting of C-Lube-10, C-PHOS-58-M, and C-PHOS-58-R.

71. The system of any one of claims 67 to 70, wherein the lubricant provides a sliding friction coefficient of less than about 0.20.

72. The system of any one of claims 67 to 71, wherein the lubricant is chemically bonded to the interior surfaces of the tubular member.

73. The system of any one of claims 67 to 71, wherein the lubricant is mechanically bonded to the interior surfaces of the tubular member.

74. The system of any one of claims 67 to 71, wherein the lubricant is adhesively bonded to the interior surface of the tubular member.

75. The system of any one of claims 67 to 74, wherein the lubricant includes epoxy, molybdenum disulfide, graphite, aluminum, copper, alumisilicate and polyethylenepolyamine.

76. The system of any one of claims 55 to 75, wherein the expandable tubular member includes:

a first tubular member;

a second tubular member; and

a pin and box threaded connection for coupling the first tubular member to the second tubular member, the threaded connection including:

one or more sealing members for sealing the interface between the first and second tubular members.

77. The system of claim 76, wherein the one or more sealing members are positioned adjacent to an end portion of the threaded connection.

78. The system of claim 76, wherein there are at least two sealing members, and one of the sealing members is positioned adjacent to an end portion of the threaded connection; and wherein another one of the sealing members is not positioned adjacent to an end portion of the threaded connection.

79. The system of claim 76, wherein there is a plurality of sealing members and some of them are positioned adjacent to an end portion of the threaded connection.

80. The system of any one of claims 55 to 75, wherein the expandable tubular member includes:

a plurality of tubular members having threaded portions that are coupled to one another by the process of:

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coating the threaded portions of the tubular members with a sealant;
coupling the threaded portions of the tubular members; and
curing the sealant.

81. The system of claim 80, wherein the sealant is selected from epoxies, thermosetting sealing compounds, curable sealing compounds, and sealing compounds having polymerizable materials.

82. The system of claim 80 or 81, further including:
means for initially curing the sealant prior to radially expanding the tubular members; and
means for finally curing the sealant after radially expanding the tubular members.

83. The system of any one of claims 80 to 82, wherein the sealant can be stretched up to about 30 to 40 percent after curing without failure.

84. The system of any one of claims 80 to 83, wherein the sealant is resistant to conventional wellbore fluidic materials.

85. The system of any one of claims 80 to 84, wherein the material properties of the sealant are substantially stable for temperatures ranging from about 0 to 450°F (about –18 to 227°C).

86. The system of any one of claims 80 to 85, further including:
means for applying a primer to the threaded portions of the tubular members prior to coating the threaded portions of the tubular members with the sealant.

87. The system of any one of claims 80 to 85, further including:
means for applying a primer to the threaded portion of one of the tubular members and the sealant to the threaded portion of the other one of the tubular members.

88. The system of claim 86 or 87, wherein the primer includes a curing catalyst.

89. The system of any one of claims 55 to 75, wherein the expandable tubular member includes:

a pair of rings for engaging the preexisting structure; and

a sealing element positioned between the rings for sealing the interface between the tubular member and the preexisting structure.

90. The system of any one of claims 55 to 75, wherein the expandable tubular member includes:

a first preexpanded portion;

a second preexpanded portion; and

an intermediate portion between the first and second preexpanded portions and including a sealing element.

91. The system of any one of claims 55 to 90, wherein the means for anchoring comprises means for explosively anchoring the expandable tubular member to the preexisting structure.

92. A system for coupling an expandable tubular member to a preexisting structure, substantially as herein described with reference to the examples.

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